TWO ALPINE WOLF SPIDERS OF AUSTRALIA: *ARTORIA ALTA* SP. NOV., AND THE MALE OF *LYCOSA MUSGRAVEI* MCKAY, 1974 (ARANEAE, LYCOSIDAE)

VOLKER W. FRAMENAU

Department of Zoology, University of Melbourne, Parkville, Victoria 3010
Current address: Department of Terrestrial Invertebrates, Western Australian Museum, Francis St, Perth, Western Australia 6000

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A new wolf spider species from the alpine region of the Australian Alps, *Artoria alta* sp. nov., is described and the male of *Lycosa musgravei* McKay, 1974 is illustrated for the first time. Dense pubescence in *L. musgravei* may have evolved as an adaptation to the alpine environment to insulate against heat loss and protect against high levels of radiation.

Key words: Wolf Spiders, *Artoria alta, Lycosa musgravei,* Australian Alps, pubescence

THE ALTITUDINAL PROFILE of the Australian Alps can be divided into three main ecological zones: alpine, subalpine, and montane (McLuckie & Petrie 1927). The alpine zone includes the area above the physiological limit of tree growth (ca. 1800 m). In the Australian Alps, it has a continuous snow cover for at least four months per year, and for six to eight months the minimum temperature is below freezing. Precipitation is high and ranges from 1,800 – 3,100 mm per year, with about 60% falling as snow (Costin 1957). Herbfields and heathlands dominate the vegetation and approximately 200 species in at least ten different plant communities are recognized (Costin *et al.* 1979). Globally, the alpine zone has its upper limit where there is a permanent cover of snow or ice (nival zone); however, the temperature regime even at its highest elevation at Mt Koseiusko (2,230m) is too warm to establish a nival zone in the Australian Alps. The subalpine zone reaches from the treeline down to the winter snowline, signified by the presence of a continuous cover of snow for at least one month (ca. 1500 m). Minimum mean temperatures below freezing prevail for about six months, and precipitation ranges from ca. 770 – 2200 mm. Snow Gum (*Eucalyptus pauciflora*) dominates the woodland, in addition to wet and dry heathland and sod tussock grassland. The subalpine zone changes into the montane zone (ca. 900 – 1500 m), with the transition from Snow Gum woodland to eucalypt forest (Costin 1975).

Despite a short vegetation period and comparatively harsh conditions, the alpine and subalpine environment host a diverse fauna. In addition to species which extend their range from lower altitudes only in the favourable summer months, some animals facultatively live above the treeline ('eualpine') or at least may be able to complete their whole life cycle there ('tyehoalpine') (Hesse 1924; 'alpine residents' in Green & Osborne 1994). Invertebrates, in particular grasshoppers and spiders, show a high number of alpine species in the Australian Alps (Green & Osborne 1994). The diversity of spiders appears to be unaffected by the change from a woodland to treeless alpine environment. About 20 families have been reported to occur in alpine and subalpine regions of the Australian Alps but a large number of species remain undescribed (Green 1988; in Green & Osborne 1994). Wolf spiders (Lycosidae) belong to the better-known taxa, and some appear to be particularly abundant in tall alpine herbfields and tussock grasslands. Three species of lycosids from the alpine region of Mt Kosciusko have been scientifically named: *Lycosa kosciuskoensis* McKay, 1974, *L. summa* McKay, 1974, and *L. musgravei* McKay, 1974, all known from females only. Other lycosids may be found at high altitudes but appear to occur mainly in forests of the montane region, such as *Venatrix funesta* (C. L. Koch, 1847) and *V. australiensis* Framenau & Vink, 2001 (Framenau & Vink 2001).

A number of morphological adaptations found in high altitude arthropods are attributed to alpine environmental conditions (Mani 1968; Sømme 1989): Increased hairiness (pubescence) is thought to serve as thermal insulation and protection against ultra-violet light; increased melanism (darkening) may improve heat absorption; and a decrease in size is thought to be due to a shorter time for growth, reduced food availability, and increased shelter options. For example, the Central European wolf spider *Pardosa saturatior* Simon, 1937, which is found above ca. 800 m is darker in colouration than its sibling species *P. wagleri* (Hahn, 1822), which mainly occurs at lower altitudes (Barthel & von Helversen 1990; Manderbach & Framenau 2001). However, *P. saturatior* is significantly larger than *P. wagleri*, contradicting the predictions of Mani (1968) and Sømme (1989).

Recent examinations of the collections of the Australian Museum, Sydney, the Australian National Insect Collection, Canberra, and the Museum Victoria, Melbourne, provided new wolf spider material from the alpine zone of the Australian Alps. The aim of this study is to facilitate the identification and study of alpine wolf spiders by describing a new species, *Artoria alta* sp. nov., and illustrating the male of *L. musgravei* of which only the holotype female was known (McKay 1974). In addition, some morphological features of these species are discussed as adaptations to the extreme conditions of the alpine environment.

MATERIALS AND METHODS

Descriptions are based on specimens preserved in 70% ethanol. The epigyne of a female *L. musgravei* was prepared for examination by submersion in 10% KOH overnight at room temperature. For clarity, the illustrations of male and female genitalic organs omit the setae. The morphological nomenclature follows Dondale & Redner (1990), Framenau & Vink (2001), and Framenau (2002).

Abbreviations

Eyes. Anterior (AE), anterior median (AME), anterior lateral (ALE), posterior (PE), posterior median (PME), posterior lateral (PLE). Measurements: total length (TL), carapace length (CL) and width (CW), abdomen length (AL) and width (AW). Genitalia: Male pedipalp: embolus (E), basoembolic apophysis (BEA), median apophysis (MA), palea (PA), subtegulum (STE), tegulum (TEG), terminal apophysis (TA). Female genitalia: copulatory duct (CD), median septum (MS), posterior transverse part (PTP), spermatheca (SP).

Collections

Australian Museum, Sydney (AM); Australian National Insect Collection, Canberra (ANIC); Museum of Victoria, Melbourne (MV).

SYSTEMATICS

Artoria alta, sp. nov.
Figs. 1A-D, 2

Material examined. Holotype. ♂, New South Wales, Mt Kosciusko NP, near Smiggin Holes, 1700 m, alpine moor, 36°24'S, 148°26'E, 7.xii.1994, coll. Daniel Biekel (AM KS44789).

Paratypes. 1 ♂, 1 immature ♀, New South Wales, Mt Kosciusko NP, Spencer Ck near Charlottes Pass, 36°24'S, 148°21'E, 28.xi.1994, coll. Daniel Biekel (AM KS45825).

Diagnosis. The shape of the MA of the male pedipalp of A. alta that has a base with two distinct groves and a triangular apical part is unique within the genus *Artoria*.

Description

Males

Carapace (Fig. 1A). Brown, with a distinct light brown median band narrowing posteriorly, constricted anteriorly of fovea, and with a narrow black median line in head region; indistinct light brown submarginal bands; dark grey radial pattern; carapace covered with short black setae except in median band; two rows of black bristles between PME, one long black bristle between AME, and two long bristles below AE. *Sternum*: Uniformly dark brown and sparsely covered with brown setae and bristles, less dense centrally. *Labium*: Brown, basally dark brown; front end truncate and white. *Chelicerae*: Uniformly dark brown; covered with few white setae and black bristles; three (holotype male four on right) retromarginal teeth, with the median largest, two promarginal teeth, with the apical larger. *Pedipalp* (Figs 1B-D): Cymbium with scopulous setae dorsally in apical half; base of MA with two distinct groves and its apical part triangular; E long and stout, resting in a groove of the sickle-shaped TA (Fig. 1D). *Abdomen*: Brown; indistinct dark median band with darker lateral borders; lanceolate heart mark in anterior half very distinct as a result of a dense cover of white

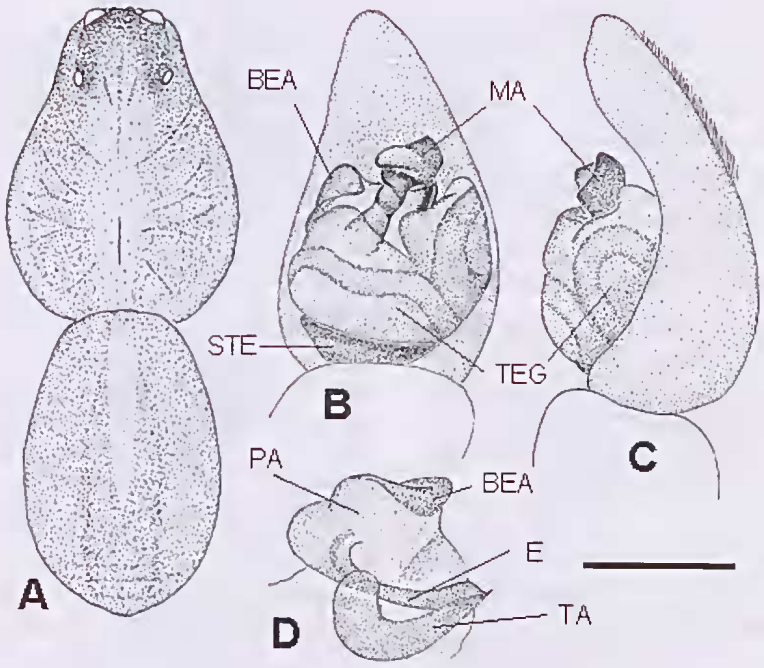

Fig. 1. Male holotype (AM KS44789) of *Artoria alta*, sp. nov.; A, male, *habitus*; B, C, left male pedipalp, ventral and retrolateral view; D, left male pedipalp, apical part of bulbus (MV KS45825). Scale bar: A, 1.5 mm; B, C, 0.34 mm; D, 0.25 mm. BEA, basoembolic apophysis; E, embolus; MA, median apophysis; PA, palea; STE, subtegulum; TA, terminal apophysis; TEG, tegulum.

setae; sparsely covered in white setae and few short, black bristles; venter light brown; setae and bristles as dorsally; spinnerets light brown. *Legs*: Leg formula IV > III > I > II; uniformly brown; spination of leg I: Femur: 3 dorsal, 1 apicoprolateral; tibia: 3 ventral pairs; metatarsus: 3 ventral pairs; 2 prolateral.

Measurements (based on holotype). TL 5.8, CL 3.0, CW 2.2. Eyes: AME 0.09, ALE 0.08, PME 0.3, PLE 0.22. Row of eyes: AE 0.54, PME 0.80, PLE 1.02. Sternum (length/width) 1.4/1.2. Labium (length/width) 0.20/0.20. AL 2.9, AW 1.9. Legs: Lengths of segments (femur + patella/tibia + metatarsus + tarsus = total length): Pedipalp 1.0+0.95+ - +0.8 = 2.75, I 2.9+2.4+1.5+0.95 = 6.75, II 1.85+2.25+1.5+1.0 = 6.6, III 1.8+2.0+1.65+0.85 = 6.3, IV 2.3+3.0+2.65+1.15 = 9.1. *Size variation* (male paratype): TL 5.6; CL 2.7; CW 1.85.

Female

Mature female unknown. The colouration of the immature paratype female is similar to the colouration of the male. Its size (TL 6.1, CL 2.55, CW 1.55) suggests a size dimorphism in this species. The female

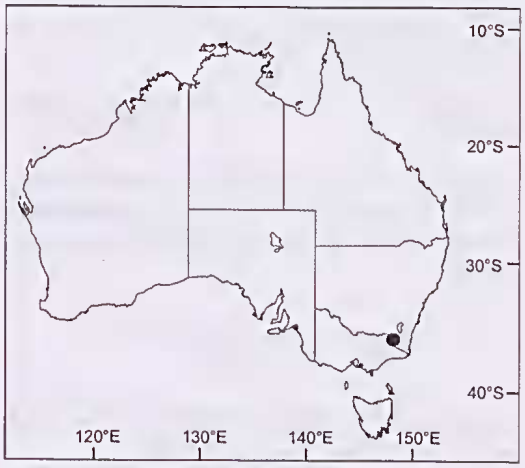

Fig. 2. Records of *Artoria alta*, sp. nov

appears to be larger, as reported in all other species of *Artoria* (Framenau 2002).

Remarks. The genus *Artoria* Thorell, 1877 was recently revised in part to include 12 Australian species, however, more than 50 species may exist (Framenau 2002). The genus is mainly defined by the presence of a broad, basoembolic apophysis (BEA), and the position (apical on tegulum) and shape (spoon-shaped or strongly bifureate) of the median apophysis of the male pedipalp. The triangular shape of the apical part of the median apophysis of A. alta represents a unique modification of the spoon-shaped form.

The subfamiliar division of wolf spiders remains controversial (e.g., Dondale 1986, Zyuzin 1993, Sierwald 2000, Vink *et al.* 2002). Recent molecular analysis supports the uniqueness of Australasian lycosid genera as suggested by distinct morphological features (Vink *et al.* 2002). In particular the male genital morphology of *Artoria*, as well as of the related New Zealand genera *Anoteropsis* L. Koch, 1878 and *Notocosa* Vink, 2002 (see Vink 2002), does not appear to conform to any of the five main lycosid subfamilies established by Dondale (1986), or the additional Evippinae and Wadicosinae (Zyuzin 1985), Piratinae (Zyuzin 1993), or Tricassinae (Alderweireldt & Joequé 1993). However, I regard the erection of a new subfamily for *Artoria*, *Anoteropsis* and *Notocosa* premature without further examining the full morphologieal variation within this group, in particular within the large number of undescribed *Artoria*.

Artoria alta, as inferred from the three specimens examined, does not show any clear morphologieal adaptations to its alpine habitat. The species is not larger, darker in its colouration (melanism) or has a denser pubescence than any other Australian *Artoria* described (Framenau 2002).

Distribution. Only known from Mt Kosciusko, New South Wales (Fig. 2).

Etymology. The species name is an adjective in apposition derived from the Latin, *altus*, meaning high, and refers to the high altitude at which this species is found.

Lycosa musgravei McKay, 1974
Figs. 3A-G, 4

Lycosa musgravei McKay, 1974: 34-35, Figs 2A-C.- Brignoli, 1983: 450; McKay, 1985: 80.

Material examined. Holotype. ♂, *New South Wales, Mt Kosciusko, 36°27'S, 148°16'E, 30.i.1966, L. Voysey (AM KS23).*

Other material examined. **Australian Capital Territory:** 1 female with spiderlings, Mt Gingera, 35°34'S, 148°47'E, 28.v.1970, coll. M. S. Upton, 5800 ft, from silk lined vertical burrow (ANIC); 1 female, Mt Gingera, 35°34'S, 148°47'E, 28.v.1970, coll. M. S. Upton, from silk lined vertical burrow (ANIC); 1 male, Mt Gingera, 35°34'S, 148°47'E, 28.iii.1970, coll. M. S. Upton, 5800ft, free ranging on snow (ANIC). **New South Wales:** 1 female, Bombala, 36°54'S, 149°14'E, i.1930, coll. A. J. Barrett (AM KS84075); 1 male, Charlotte Pass, Mt Koseiusko, 36°24'S, 148°19'E, 8.v.1980, coll. J. Balderson (ANIC); 1 male, 1 female, Crackenback Peak, 36°24'S, 148°32'E, iii.1964, coll. W. A. Howard (ANIC); 2 females, Gungarlin River (tributary of Snowy River), 36°17'S, 148°52'E, no date, coll. R. J. Jenner (AM KS84081); 1 female, Kiandra, 35°52'S, 148°29'E, 21.ii.1960, coll. E. F. Rick (ANIC); 1 female, Mt Kosciusko, 36°27'S, 148°15'E, no date, 6000ft (AM KS84082); 1 male, Mt Kosciusko NP, Wraggs Ck/Pipers Creek Aquaduct, 36°32'S, 148°28'E, 31.iii.1982 (ANIC); 1 female, Perisher Range, East of Guthega Dam, 36°25'S, 148°25'E, 28.i.1962, coll. K. Horne, 5500ft, in burrow (AM KS84079); 1 female, Speneers Creek, Mt Koseiusko, 36°27'S, 148°16'E, 22.xi.1952, coll. A. Musgrave, 1000m (AM KS70010); 1 female, Speneers Creek, Mt Kosciusko, 36°27'S, 148°16'E, 24.xi.1952, coll. A. Musgrave, 1000m (AM KS70012); 1 female, Speneers Creek, Mt Kosciusko, 36°27'S, 148°16'E, 23.xi.1952, coll. C. E. Chadwiek, 1000m (AM KS70013); 1 female, Tumut, 35°18'S, 148°13'E, 7.iii.1949, coll. S. Bayliss (AM KS84080); 1 female, Tumut Pond, 35°18'S, 148°13'E, 20.xii.1951, coll. K. R. Sharp (AM KS82593). **Victoria:** 2 females, Elsternwiek, 37°53'S, 145°00'E, 20.i.1954, coll. Mr Brownlie (MV K8095, K8209); 3 females, Hotham Heights, 36°59'S, 147°08'E, xii.1933, coll. A. Musgrave (AM KS84076, KS84078); 1 male, Mt Bogong, 36°44'S, 147°18'E, 21.ii.1972, coll. C. Kohlman (MV K8204); 1 male, Mt Bogong, 36°44'S, 147°18'E, 21.ii.1972, coll. C. Kohlman (MV K8207); 1 female, Mt Buffalo, 36°46'S, 146°46'E, xii.1933, coll. A. Musgrave, 4000ft (AM KS84077); 1 female with eggsae (106 larvae, 71 undevelopped eggs), Mt Gibbo, 36°36'S, 147°57'E, 15.i.1975 (MV K8094); 1 female, Mt Hotham, 36°59'S, 147°08'E, i.1945, 6000ft (MV K8205); 1 female, 1 male, Mt Hotham, summit,

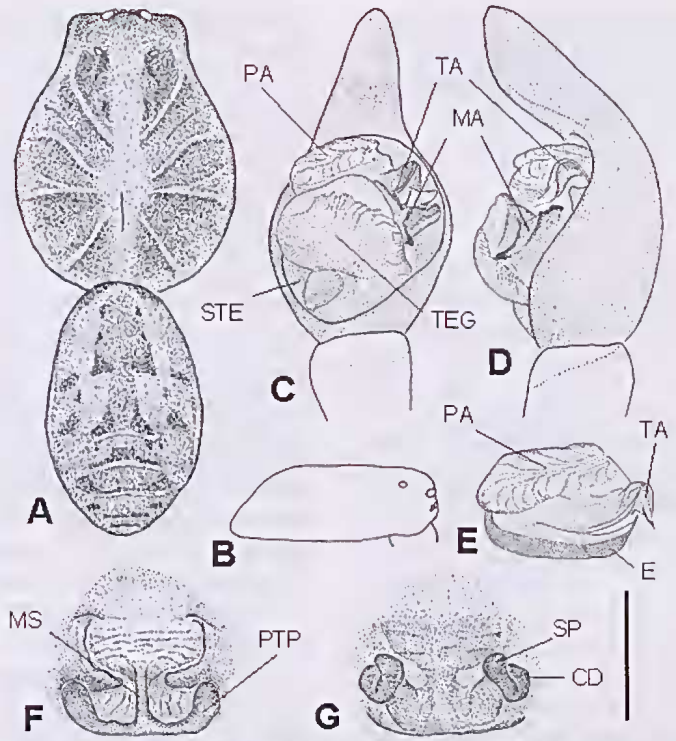

Fig. 3. Male (MV K8204) and female (MV K8095) of *Lycosa musgravei* McKay. A, male, *habitus*; B, carapace, lateral view; C, D, left male pedipalp, ventral and retrolateral view; E, left male pedipalp, apical section of bulbus; F, G, female epigyne, ventral and dorsal view. Scale bar: A, 4.6 mm; B, 6.2 mm; C, D 1.58 mm; E, 1.24 mm; F, G, 1.67 mm. CD, copulatory ducts; E, embolus; MA, median apophysis; MS, median septum of epigyne; PA, palea; PTP, posterior transverse part; SP, spermatheca; STE, subtegulum; TA, terminal apophysis; TEG, tegulum.

36°59'S, 147°08'E, 27.i.1973, coll. M. Pearce, 6100ft, (MV K8206, K8208); 1 female, North Mt Phipps, 1.5km SW Moe, Head of Spring Ck, 37°12'S, 147°26'E, 28.xii.1989, coll. Heath Morris, 4000ft (MV K8166).

Diagnosis. *Lycosa musgravei* is similar in general appearance to *L. gilberta* Hogg, 1905, *L. godeffroyi* L. Koch, 1865 and *L. leuckartii* (Thorell, 1870), three species commonly found in lowland areas of southern and south-eastern Australia (Queensland, New South Wales, Victoria, South Australia, and Western Australia). Males can be distinguished by the shape of the TA, which is double-lamellar in *L. musgravei*, but simply sickle-shaped in *L. godeffroyi* and which forms a wave-like structure in *L. gilberta* and *L. leuckartii*. The lateral tips of the PTP of the female epigyne are strongly curved anteriorly in *L. musgravei*, but point laterally in *L. gilberta*, *L. godeffroyi* and *L. leuckartii*. The abdominal pattern of *L. musgravei* differs distinctly from that of the other two large, alpine lycosids, *L. kosciuskoensis* ('dark brown longitudinal spot surrounded by narrow fawn band that becomes somewhat

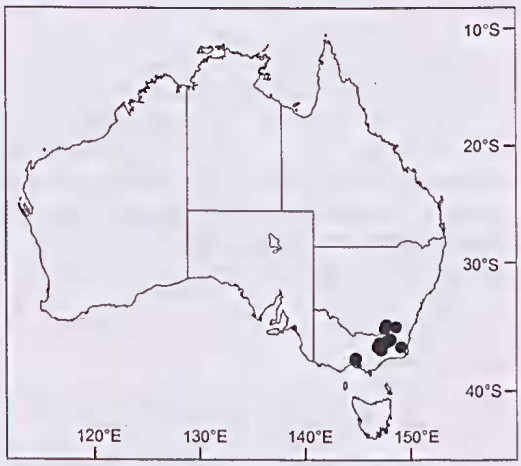

Fig. 4. Records of *Lycosa musgravei* McKay.

diffuse posteriorly') and *L. summa* ('pale brown to fawn (...) longitudinal stripe (...) encloses a dark brown hastate stripe anteriorly') (descriptions cited after McKay 1974; also pers. observation).

Description

Males

Carapace (Fig. 3A-B). Dorsal line in lateral view straight from head region to fovea, then abruptly descending (Fig. 3B); dark reddish brown with light brown median band and four white, but dark edged, radial stripes, the anterior ones reaching below PLE; indistinct light brown submarginal bands; carapace densely covered with short black setae with the exception of head region, median band and light radial stripes which are densely covered with white setae; black bristles in head region and lateral of PLE; one long, black bristle between AME and four long bristles below AE. *Sternum*: Light brown, densely covered with black setae; fewer bristles increasing in length towards margins. *Labium*: Dark brown, front end truncate and light. *Chelicerae*: Reddish brown; densely covered with white setae and fewer black bristles; three retromarginal teeth of similar size, three promarginal teeth with the median largest and the two apical ones fused at the base. *Pedipalp* (Figs 1C-E): Lateral tip of MA with little apical teeth; E broad over all of its length; TA a double lamellar structure with its tip bent basally (Fig. 1E). *Abdomen*: Brown; light brown median band in anterior half contains a double wedge-shaped, dark marking with elongated, black posterior ends; four to five dark chevrons in posterior half; densely covered with setae of variable colour corresponding to abdomen colouration; lateral light brown with dense cover of white setae; venter black with dense cover of black setae; spinnerets dark brown. *Legs*: Leg formula IV > III > I > II; uniformly brown; dense, scopulous setae on all tarsi, metatarsi I and II, and in apical half of metatarsus III and apical third of metatarsus IV; spination of leg I: Femur: 3 dorsal, 2 apicoprolateral, 2 retrolateral; patella: 1 prolateral, 1 retrolateral; tibia: 2 dorsal; 3 ventral pairs, 2 prolateral, 2 retrolateral; metatarsus: 2 ventral pairs; 2 prolateral, 2 retrolateral, 2 small apicoprolateral; 2 small apicoretrolateral.

Measurements (based on MV K8204). TL 18.0, CL 9.9, CW 7.3. Eyes: AME 0.34, ALE 0.35, PME 0.7, PLE 0.60. Row of eyes: AE 1.8, PME 1.9, PLE 2.4. Sternum (length/width) 4.2/3.0. Labium (length/width) 1.1/1.3. AL 3.0, AW 1.8. Legs: Lengths of segments (femur + patella/tibia + metatarsus + tarsus = total length): Pedipalp 3.5+3.4+ - +3.8 = 10.7, I 8.0+10.2+7.2+4.1 = 29.5, II 7.4+8.8+6.7+4.0 = 26.9, III 6.5+7.5+6.3+3.7 = 24.0, IV 8.1+10.3+8.7+4.5 = 31.6. *Size variation* (range, mean ± SE): TL 19.0 – 20.6, 19.6 ± 0.9; CL 9.9 – 11.5, 10.7 ± 0.8; CW 7.3 – 8.3, 8.1 ± 0.7; n = 3.

Females

The female of *L. musgravei* is described in detail in McKay (1974). Cephalothorax colouration agrees with that of the male, the abdominal pattern is less distinct. The epigyne of a specimen collected in Victoria is depicted here in ventral (Fig. 3E) and dorsal view (Fig. 3F) to illustrated diagnostic features. Size variation of the material deposited in the MV is given, as only the holotype female was previously known (McKay 1974). *Size variation* (range, mean ± SE): TL 21.0 – 28.5, 24.3 ± 2.8, n = 5; CL 11.0 – 15.0, 12.9 ± 1.3, n = 6; CW 8.3 – 11.1, 9.6 ± 1.1; n = 6.

Remarks *Lycosa* Latreille, 1804 has recently been suggested to be an exclusively Mediterranean genus (Zyuzin & Logunov 2000). In addition, preliminary molecular data suggests that some of the large burrowing lycosids of Australia, of which *L. musgravei* is part of and which were represented in their analysis by *Lycosa godeffroyi*, is close to the North American genus *Geolycosa* Montgomery (Vink et al. 2002). However, the generic description of *Geolycosa* does not match the Australian species (e.g. Dondale & Redner 1990): the dorsal profile of the carapace of *Geolycosa* is highest in the caput region, followed by a gentle slope towards the posterior cephalothorax margin, whereas the dorsal profile of *L. musgravei* is straight over most of the carapace and descends sharply behind the fovea (Fig. 3B). In addition, *Geolycosa* does not have light median and submarginal bands and a Union-Jack-pattern of white radial bands on the carapace which are present in *L. musgravei, L. gilberta, L. godeffroyi* and *L. leuckartii*. Three recent revisions of Australasian lycosid genera, *Allotrochosina* Roewer, 1960, *Artoria* Thorell, and *Venatrix* Roewer, 1960, suggest the uniqueness of the Australasian fauna (Vink 2001; Framenau & Vink 2001; Framenau 2002). Likewise, *L. musgravei*, and all other Australian lycosids placed in Lycosa, almost certainly belong to different, most likely new genera; however, *L. musgravei* is retained in *Lycosa* pending a full generic revision of Australian wolf spiders, which is currently

being conducted by the author at the Western Australian Museum.

The whole body of *L. musgravei* is covered with a very dense layer of setae and bristles, which are much denser than in any of the specimens of the related species *L. gilberta*, *L. godeffroyi* or *L. leuckartii*, (pers. observation). This dense pubescence conforms to one of the adaptations of high altitude arthropods to insulate against heat loss and protect against high levels of radiation (Mani 1968, Somme 1989).

Habitat and phenology. *Lycosa musgravei* is reported to be the most frequently observed wolf spider in the Snowy Mountains, with their open burrow found in tall alpine herbfields and grasslands (Green & Osborne 1994). The burrow (closed with a thick sheet of webbing in winter) is raised above ground level by inclusion of an open turret of web and vegetation litter (Green & Osborne 1994). The records of two females from Elsternwick (suburban Melbourne) seem to be unusual for this apparently alpine spider, and may be the result of human recreational activities.

Mature females were found from November through to May with the exception of April, with most records in December and January. One female with eggsac and a female carrying young were collected in December and May respectively. Mature males were found between January and May, with the exception of April as in females.

Distribution

Australian Capital Territory, New South Wales and Victoria (Fig. 4).

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